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ABSTRACT

The paper reports observations from a 2-year investigation of teaching/learning processes as they occurred during microcomputer instruction in three special education schools. Factors in the learner and/or learning environment are analyzed for their effects on the development of problem solving strategies. Part 1 reports observations of behavior of 212 3-to-12-year-olds with language or cognitive impairments in three microcomputer environments (instructional software, Logo, and teacher mediated learning). Behaviors were classified according to a scheme of cognitive distancing. Findings revealed relationships between age and level of cognitive distancing for all treatments, and between treatment and level of cognitive distancing for all ages. Part 2 of the study examined the realtionship between performance in Logo instruction and level of cognitive development from a perspective based on L.S. Vygotsky's theories. A concept attainment task was administered to 15 Ss randomly selected from the larger group targeted for observation. Behaviors on this task were compared to behaviors demonstrated by Ss during interactions with Logo. Results suggested a strong relationship between level of cognitive development and ability to profit from Logo instruction. (Author/CL)

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The Teaching/Learning Process of Handicapped Children in the Microcomputer Environment

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This paper reports observations from a two-year investigation of actual teaching/learning processes as they occurred during microcomputer instruction in three special education schools. It addresses the issue of what factors in the learner and/or learning environment might affect the development of problem solving strategies. Part 1 reports systematic observations over the course of a semester of the behavior of 212 subjects, ranging in age from 3 to 12 years old and classified as having some language or cognitive impairment, in three distinct microcomputer environments, i.e., instructional software, Logo, and teacher mediated learning (control). These behaviors were classified on an observation instrument based on Sigel's (1970, 1977) model of cognitive distancing. Findings revealed relationships between age and level of cognitive distancing for all treatments, and between treatment and level of cognitive distancing for all ages. Part 2 of the study examined the relationship between performance in Logo instruction and level of cognitive development from a Vygotskyan perspective. A concept attainment task modeled on one used by Vygotsky (1962) was administered to 15 subjects selected at random from the larger group targeted for observation. Behaviors on this task were compared to behaviors demonstrated by subjects during interactions with Logo. Results suggested a strong relationship between level of cognitive development and ability to profit from Logo instruction. Implications for computer instruction are discussed.

Microcomputer instruction has become an area of increasing interest for those concerned with educating cognitively and language impaired children. Particularly Logo, a programming language purported to utilize childrens' problem-solving abilities (Papert, 1980), has been viewed as a promising use for microcomputers in the education of children who manifest deficits in the area of representational thinking and problem solving (Budoff & Hutton, 1982).

A great deal has been written in recent years about the relative difficulty that learning disabled and other handicapped children manifest in using efficient problem solving strategies in their learning (Copeland & Weissbrod, 1983). These strategies include planning, analysis, monitoring, evaluating and modifying (Brown, 1981; Brown & DeLoache, 1978). Some studies have suggested that it may be possible to train children to use more efficient strategies and thus improve their performance on specific tasks (Torgesen, 1977; Torgesen, 1979), but results have varied according to what skills were actually taught and also according to the context in which they were taught. Few studies have documented successful teaching of higher level, hierarchically integrated skills. Further, there has been little evidence of the transferability of trained problem-solving skills across domains. Research has only fueled the debate of whether development must precede the learning of certain concepts (Piaget, 1964), or whether concepts and strategies are a result of learning (Skinner, 1938).

The promise of Logo as a vehicle for developing powerful and potentially generalizable metacognitive skills, through active

interaction between the child and the "turtle", has prompted its increasing use in education and special education as well. Logo research to date has generally centered on the issue of transferability, addressing the question of whether those metacognitive skills purported to be utilized in Logo programming affect performance in other domains (Clements & Gullo, 1984; Leherer, 1984; Harckham, et al, 1985; Pea & Kurland, 1984). The Nassau County BOCES Microcomputor Research Project, the larger project within which the current investigation took place, examined the effects of various microcomputer experiences on the problem solving and academic achievement of handicapped children. A major accomplishment of research staff was the development and validation of an observation instrument whereby teaching and learning in the microcomputer setting can be classified within a cognitive distancing framework (Sigel, 1970; Sigel & Cocking, 1977).

Early in the two year research study, however, it became clear that any investigation into transferability of problem solving skills from Logo experience to other academic domains might be placing the cart before the horse. A more pertinent question concerned the extent to which children were actually utilizing higher order thinking skills during the course of their experience with the microcomputer. This seemed to vary from school to school, from class to class, from child to child. In other words, the particular software environment to which a child was assigned did not appear to be the true independent variable affecting outcome. Rather, two other variables seemed to be crucial to the learning climate in all three treatment groups.

The first concerned teaching strategies utilized by teachers in their particular implementations of microcomputer software, which in turn reflected individual training, teaching style, and conceptual framework for educating handicapped children. The other variable concerned the child's level of cognitive development, reflecting both age and handicapping condition, and its relation to effective utilization of the Logo experience for the developemnt of problem-solving skills.

This paper reports the findings from two observational studies, conducted during the two year period of the larger microcomputer project. Neither study was intended to investigate outcomes, but rather to systematically observe teachers and children engaged in the teaching-learning process during microcomputer instruction. Study 1 addresses the cognitive distance (Sigel, 1970; Sigel & Cocking, 1977) of behaviors initiated by teachers, children, and/or software in three distinct microcomputer treatment groups. Study 2 examines the cognitive developmental level of handicapped children as reflected in their performance on a Vygotskyan categorization task (Vygotsky, 1962), and its relation to their use of high cognitive distance behaviors when engaging in Logo instruction. The theoretical rationale for both studies, as well as for much of Sigel's work on teaching and learning strategies (Pellegrini, Brody & Sigel, 1985) stems from Vygotsky's 1962 and 1978 paradigm of learning and development.

Review of related theories

Any investigation into the implementation of microcomputers with cognitively or language impaired children must first consider the theoretical underpinnings of pedagogical practices currently in use with special populations. Certainly in America, the most prevalent and for many years unchallenged paradigm for teaching and learning was behaviorism (Thorndike, 1913; Skinner, 1938).

From a behaviorist perspective the classroom is an environment of stimuli which develop, maintain, and change the responses of a learner (Skinner, 1938). Growth and development are defined as the accumulation of many individual learned responses. A teacher's role in the behavioral learning model is to develop behavioral objectives, sequence the presentation of skills and concepts toward meeting these objectives, and supply the necessary reinforcement to assure mastery of the goal. Implicit in the behaviorist paradigm is the assumption that higher level concepts are inclusive of lower level skills which are teachable if reinforced. Behaviorist research has rarely questioned whether a concept is truly the sum of its parts, but rather it has focused on the relationships among temporal placement of reinforcers and the acquisition or extinction of responses (Lindsley, 1969; Skinner, 1938; Bucher & Lovaas, 1967). Behavior modification, a teaching method whereby successive approximations of the desired behaviors are consistently reinforced in the classroom, is still very much in vogue in many special education programs. It can hardly be questioned that children do master many behavioral objectives in such modification programs. Of question, however, and certainly a

subject being addressed in current research on cognitive training (Brown, 1981, 1982; Brown & DeLoache, 1978; Borkowski & Cavanaugh, 1979) is whether executive processes can actually be broken into smaller components which are teachable. Further, once they are broken into component parts, we might ask: are we really training higher order thinking processes that are generalizable, or simply maintaining the illusion that we have done so?

Another unquestionable influence in educational theory, although to a lesser extent on teaching methodology, is the work of Jean Piaget. Of fundamental concern in Piagetian theory is the identification of processes underlying changes in thinking throughout a child's development. Factors which affect the progression are both neurological maturation, which determines an invariant sequence of developmental stages, and experiential interaction with persons and things in the environment. These maturational stages have often been viewed as thresholds below which certain types of learning, in the adult sense, are inappropriate or impossible. It is this normative description of development which has fueled research in the area of cognitive training. Generally, a review of Piagetian training studies (Smith, 1975) would caution against a literal acceptance of predetermined thresholds, and perhaps provide some modification of the view that the processes of development are independent of learning. Piaget's view was that learning utilizes the achievements of development, rather than providing an impetus for modifying its course. Equally important, however, is the idea that this learning is active and interactive, that cognitive

structures develop not from using rules somebody else has developed, but by constructing and understanding these rules oneself.

Both sets of theories are relevent to microcomputer instruction in terms of software content and in terms of teacher implementation. Much of our current educational materials, including most newly developed software (Vota, 1985), was designed from a behaviorist point of view. Software is most often geared toward the development of individual subskills such as phonics, computation, or isolated reading comprehension techniques. These skills are generally reinforced in increments as a child progresses through a sequence of instruction.

At the same time, Logo, with its origins in Piaget's concepts of learning through interaction, seems to represent a viable alternative to drill and practice programs (Papert, 1980). Learning Logo should, according to Papert, be an active process of self-discovery. Papert emphasized that aspect of Piaget which stresses the natural, spontaneous, learning of people in active social and cognitive interaction with their environment, as opposed to the "curriculum-driven learning characteristic of traditional schools" (p. 156). A teacher's use of the program, however, may well reflect the notion of behaviorist hierarchies as applied to Logo skills. In other words, if a teacher chooses to view Logo programming as a series of subsets which will ultimately enable a child to make products, i.e., "the box", much of Logo's potential for stimulating intellectual interaction with the computer may be lost.

Another consideration addresses the issue of whether

independent learning can take place on Logo if the child has not reached some level of abstract thinking ability. Papert (1980) chooses to ignore that aspect of Piaget which deals with inherent stages of cognitive development as necessary precursors to learning, and rejects them as a "conservative, almost reactionary" theory which emphasizes what children cannot do (p. 157). Nevertheless, some consideration must be given to this component if the overall process is to be properly understood.

Another question of interest in concerns what role the teacher can play in optimizing the potential of the microcomputer to provide the experience of interaction with the environment which it was hoped (Papert, 1980) would encourage the growth of planning and strategic problem-solving skills in children and enhance intellectual growth. A rigid adherence to the behaviorist view, in which the external events of learning itself are seen to constitute development, runs the risk of reducing learning from manageable chunks into irrelevant bits. On the other hand, a predeterminist view of learning along strictly Piagetian lines, which emphasize internal structures, can easily lead to the view that educational intervention is of minor value in the developmental process (Sullivan, 1968). Thus, one must focus, as Papert did, on the "intellectual structures that could develop as opposed to those that actually at present do develop in the child, and (on) the design of learning environments that are resonant with them" (p. 161).

The zone of proximal development

The link is found in the work of Lev Vygotsky (1962, 1978),

who stresses the relationship of the dual factors of maturation and learning. These two processes are seen to constitute development, and they are mutually dependent and interactive. The process of maturation prepares and makes possible certain kinds of learning. The learning, in turn, stimulates and pushes forward the maturation process. This interrelationship exists from the child's very first day of life. Much of this learning, in Vygotsky's view, is provided through the vehicle of language, and by means of the child's interactions with the adults in his life, parents and teachers. Through adult-child dialogues adults teach children to plan and guide their behavior. Such adult- or other-directed teaching strategies are necessary, in this model, if children are to become self-directed problem solvers. Children move from others' regulation to self-regulation through the internalization of adult-provided learning strategies. As children develop, this adult scaffolding of childrens' behavior diminishes, and the children themselves assume greater responsibility in task situations.

The distance between those functions in children that have not yet matured but are in the process of maturation, and the actual developmental level, which defines functions that have already matured, constitutes the zone of proximal development (Vygotsky, 1978). Whereas a view of levels of maturation characterizes mental development retrospectively, the zone of proximal development characterizes mental development prospectively. It accounts for the fact that children whose levels of mental development are equal may vary considerably with regard to their ability to learn under a teacher's guidance. The

zone of proximal development is then the distance between the actual developmental level of the child as determined by independent problem solving abilities, and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. The question of interest, then, becomes one of what are the characteristics of this interaction between adult and child (or between child and computer software) which promote this progression through the zone of proximal development.

Vygotsky has not been alone in emphasizing the role of external factors in promoting the intellectual development of children. Bruner has stated (Bruner, et al, 1967) that "cognitive growth in all its manifestations occurs as much from the outside in, as from the inside out" (p.2). Cognitive development, in Bruner's view, is affected by the internalization of tools provided by a given culture. Some environments stimulate cognitive growth earlier and longer than others. School learning, in particular, fosters and demands more abstract modes of thought. In fact, the school environment may provide, in the view of Feuerstein (1980), a unique opportunity to modify a child's existing cognitive structures through intervention (i.e. Instrumental Enrichment). This modification can lead, according to this theory, to the alteration of the course and direction of cognitive development. This intervention, in the form of interaction between the child and the adult community in the mediated learning experience, plays a definitive, causal role in cognitive growth.

Cognitive distancing and the zone of proximal development

Sigel & Cocking (1977) extended the stage dependent theories of Piaget. The concept of cognitive distancing elaborates a communication model for the study of representational thinking. Although Piaget indicated that social factors affect cognitive development (Piaget, 19), he failed to clarify their nature. The model of distancing, discrepancy and dialectics (Sigel, et al, 1977), is a description of the social process of stage transformation in representational thought.

In this model the symbolic processes which pave the way for the development and use of metacognitive learning strategies may be enhanced by the sequential presentation of stimuli which place cognitive demands on the child. Through such demands cognitive distance is created between the child and his immediate context. Thus, a mental discrepancy is formed which the child must resolve. The only way a child can respond is to produce those mental activities required by the demand. Through dialectics a child's constructs change through resolution of the discrepancy created by the adult's questions.

Level I contains behaviors which are bound to the child's perceptions, such as labeling, observing, and describing. Level II entails the ordering of perceptions in some way. Behaviors at this level include simple sequencing, estimating, and comparing, where the object of a child's endeavors is always available within the immediate environment. Level III includes those behaviors aimed toward the achievement of the goals themselves. To achieve goals, children must plan, sequence, and monitor their actions, thus engaging in those strategies considered important in

problem solving (Brown, 1981). Type of teaching behavior as well as type of software can be considered channels for providing children with discrepant information, thus promoting the use of progressively higher order thinking skills.

Vygotsky's zone of proximal development is relevant to the distancing model in that it delineates both an upper and lower parameter for determining a child's potential for gain from parental or teacher distancing strategies. In other words, Piaget identified the variable of social interaction in development. Sigel, et al (1977) described the distancing behaviors which comprise this social interaction, and Vygotsky presented the boundaries for determining which distancing behaviors will effectively stimulate childrens' symbolic processes and which behaviors will be futile for promoting learning. He described these parameters at the lower level as that which the child can do independently, and at the upper level, as that which the child can do with assistance. "The only way a child can answer a question is to become actively engaged, producing those mental activities demanded by the inquiry" (Sigel,et al, 1977, p. 213). But in order for the child to actively engage in such mental activities as Sigel describes, the demand must be within his zone of proximal development.

These theories are relevant to computer instruction in several ways. Most instructional software for classroom use has goals well established and incorporated into the reinforcement system. Children who use them are required to do very little in the way of planning or self-monitoring during their progression through instruction. The programs themselves are generally

pre-sequenced and self-correcting, thus making it unnecessary for children to use metacognitive strategies either in establishing goals or in achieving them. Simulations might be considered the exception to this rule although most of these require reading skills, thus precluding their use by a majority of young children and by many older impaired children. Most of the instructional programs used by students in microcomputer instruction are therefore of a drill and practice nature.

Logo, on the other hand, has the potential of promoting greater use of metacognitive strategies because goals for its use can be conceptualized by the user. A child might decide to sequence the commands necessary to draw a simple square or perhaps a more complicated procedure such as making a flag or different sized squares. Even single keystroke programs, which eliminate much of the potential for actual programming, still make it possible for a young child to plan a picture and monitor his/her activities accordingly. Use of Logo programs to increase the use of problem solving strategies, however, can depend greatly on their implementation by the teacher. If a teacher consistently defines goals for children and/or dictates the sequence of procedures necessary to achieve these goals, much of Logo's potential for promoting metacognitive skills may be lost even though the children are producting elaborate pictures. In such a situation products are taking precedence over process.

A question of interest is whether variations in teaching styles interact with programs in different ways. Do teachers differ in their use of distancing behaviors when instructing children with Logo as compared with instructional software

programs or non-computer materials? Further, are there variations in ways children of different age levels interact with computer programs?

The Microcomputer Observation Instrument developed in this study uses a cognitive distancing framework (Sigel, 1970; Sigel & Cocking, 1977).* The instrument makes it possible to classify and quantify both teacher and child behaviors in the computer setting by placing these behaviors at one of three levels of distancing. These behaviors are coded according to their source, i.e., teacher or student, which makes it possible to determine on which programs teachers and children are most likely to engage in higher levels of problem solving. Because they are also coded for adequacy of response, it is possible to determine if, in fact, childrens' activities and responses at these higher levels are successful. "How sensitive the adult is to the child's ability to comprehend the particular behavior in question will be guaged by the adult's awareness of the child's response" (Sigel,et al, 1977, p. 215).

Study 1: Observational Data

Method

Subjects

In the larger Nassau BOCES Microcomputer Study of which this was a part there were approximately 700 subjects in four special education schools. The children had been classified as learning disabled, emotionally handicapped, speech impaired, retarded,

* The authors' thanks are expressed to Richard Lehrer for his suggestion of Sigel's model and for assistance in the initial stages of developing the instrument.

autistic, or multiply handicapped. Subjects had been randomly assigned to one of three treatment conditions: teacher-directed learning (control), instructional software (IS), and Logo. Children were randomly assigned to the three groups within each school. They received instruction for three 30-minute periods each week in their school's Learning Center which housed Apple and Texas Instruments microcomputers.

Within each class of the four target schools, three students were randomly selected for observation, one from each treatment group. They were selected from a total of 22 classes of eight to twelve year olds, 33 classes of five to eight year olds, and 16 classes of three to five year olds. A total of 212 subjects were targeted for observation, with an equal number of alternates to be observed on occasions when targeted students were not available. All were classified as having some language, emotional, or cognitive impairment. A total of 229 different subjects were systematically observed from 1 to 19 times each throughout the semester.

Instrument

Behavioral categories within each level of distancing as presented in Sigel's (1970) model were collapsed into a total of 21 cells. For example, evaluating consequences, evaluating effect, and evaluating effort were combined into one category called strategic monitoring, wherein the child was seen to use metacognitive behaviors in pursuing a course

of action. Although original levels of distancing were left intact, individual cells were adapted to reflect behaviors observed frequently by the research team in the microcomputer setting. These categories were set forth in behavioral terms through observation and analysis of videotaped classroom lessons. A method of coding was developed whereby the source of a particular interaction, i.e., teacher or student, as well as the adequacy of the child's response could be noted within each category of behavior. This made it possible to consider many combinations of variables includingthe intended level of the teacher's lesson, the ability of the child to interact with the teacher or software at a given level, and the frequency of Level III problem solving behaviors (see above) as they occurred in a Logo environment as compared to IS or control environments. Date, type of software, and teacher of each lesson were recorded as well as social facilitation factors including attentiveness and cooperativeness during lessons.

Procedure

Members of the research team were assigned to observe in one of the four target schools for a semester. During each twenty-minute class, a Logo student was observed for ten minutes. The other ten minute period of observation was alternated weekly between instuctional software and control students. The first half of each observation period was alternated between treatments to control for differences due to fatigue or attentional factors. Interactions during

lessons were systematically coded for the variables of level, category, initiator, and adequacy. Frequencies for each of the aforementioned variables were converted to percentages of total interactions within each treatment group. These percentages provide a description of differences in the learning process across treatments and age levels.

Results

Age/Level

Results showed a relationship between age and level of cognitive distancing for all treatments, as can be seen in Figures 1 and 2. The highest proportion of Level III problem solving strategies occurred in the Logo group of eight to twelve year olds. Level I interactions which included labeling, observing and identifying things in the immediate environment predominated all three treatment groups of three to five year olds with the largest proportion occurring in teacher directed activities (control).

Treatment/Level

A relationship between treatment and level of cognitive distancing emerged in the observational data. As can be seen in Figures 1 and 2, a greater proportion of Level III problem solving interactions occurred in the Logo treatment

group across all age groups than in either the IS or control groups.

Level II behaviors which included sequencing, comparing, and generally restructuring perceptions in some way predominated the instructional software in the eight to twelve year old group, with 88% of total teacher-child interactions falling into this category. Because many activities which require selective analysis of perceptions are encompassed within beginning reading and mathematics, the programs designed to drill these skills were used heavily by teachers of the 8-12 year old group. Figure 3 presents a composite picture of cognitive distance levels within each treatment group across ages.

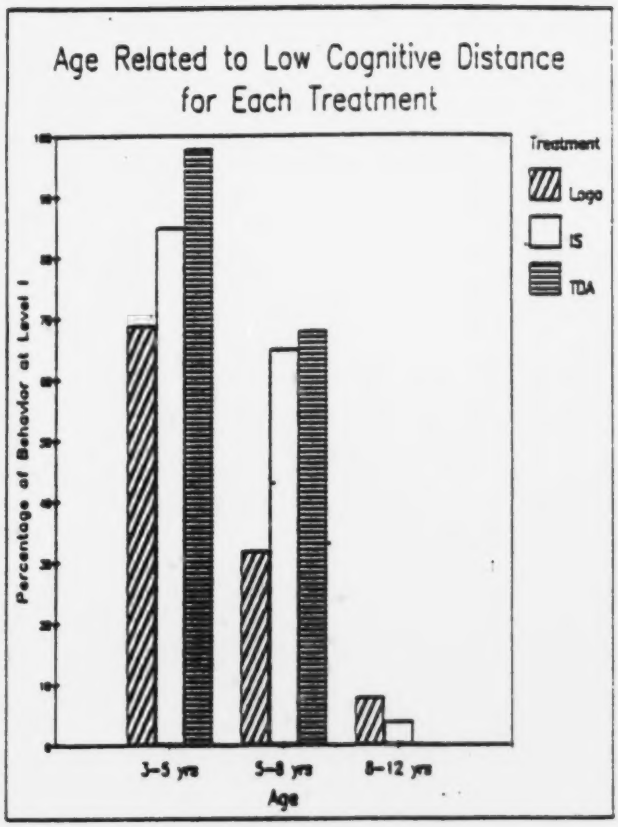

Figure 1

Figure 2

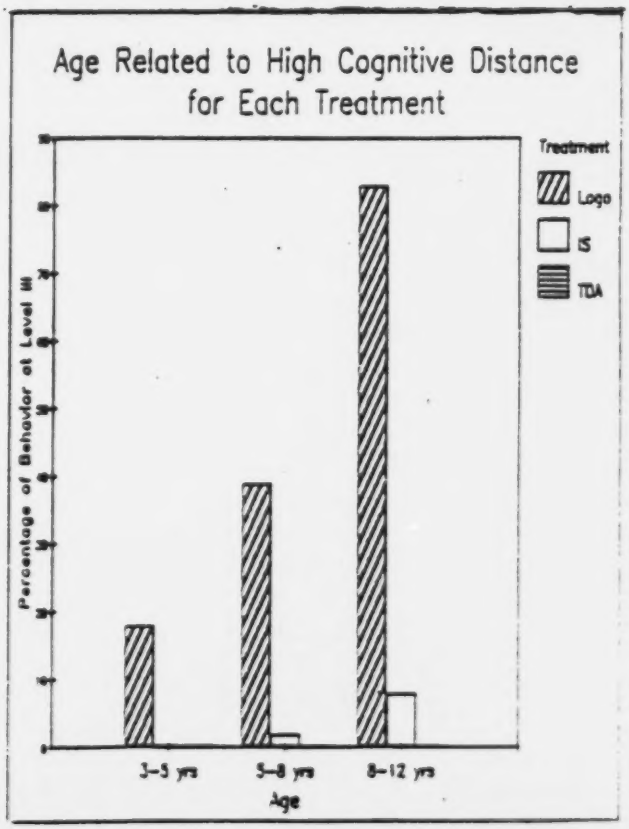

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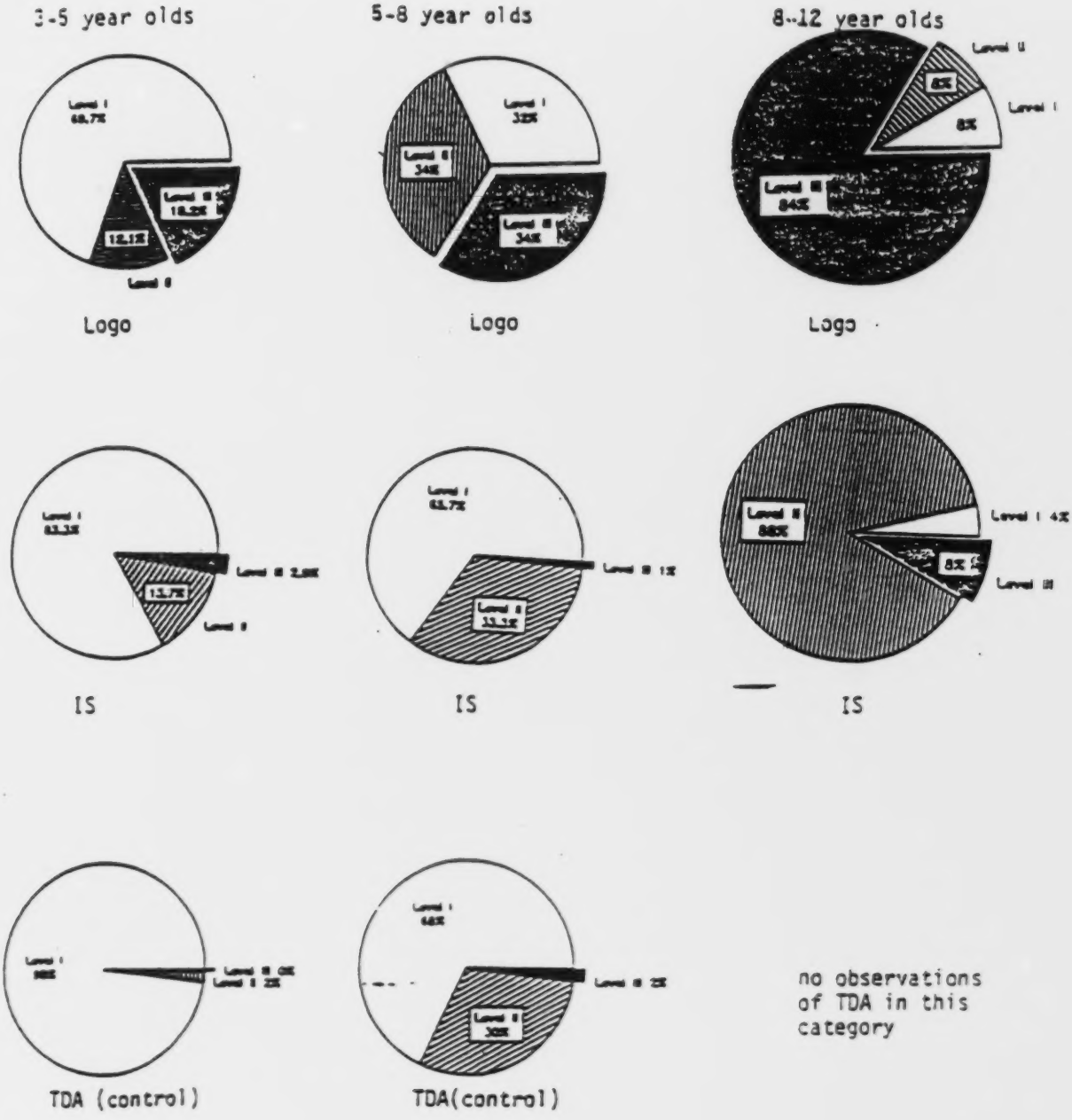
Figure 3. Cognitive Distancing Level of Teacher/Child Interactions by Treatment and Age



Teacher initiation: age/level/treatment

Table 1 presents the percentage of teacher initiated interactions by age, level, and treatment. It may be seen in the table that teachers initiated more interactions at the lowest level of distancing than at higher levels and more so in Logo than in either teacher directed or instructional software groups.

Table 1

Percentage of Teacher Initiated Interaction at Three Levels of Cognitive Distancing by Treatment

Treatment	Percentage of Teacher-Initiated Interactions		
	I	II	III
Logo	72	63	37
IS	64	30	12
TDA	62	50	no observations

An additional analysis of response adequacy data provided evidence that across age groups, 72% of all teacher-initiated interactions at Level III were met with successful response on the part of the students. A similar high rate of success, 82%, occurred for spontaneous interactions at Level III across age groups. It is important to reiterate here that Level III behaviors rarely occurred in any treatment other than Logo.

Discussion

Several noteworthy aspects of computer instruction have emerged from this study which may point the way for future investigations of this nature. First, a clear relationship beween age and level of cognitive distance emerged across treatments. The proportion of Level I behaviors was highest among the youngest children, and conversely, older children engaged in higher levels of behavior. At the same time, teachers initiated the interactions more often with younger children. These data are consistent with DeLoache's findings (cited in Brown, et al, 1983) that mothers provided young children with more support than older children in a learning situation. Also, mothers of younger children were more directive, i.e., they pointed to and labelled objects for children.

The relationships between treatment and level of cognitive distance were striking in that by far the largest proportion of Level III behaviors occurred in Logo and Logo-related environments. In fact, Level III behaviors rarely occurred in any other treatment group. Concerning source of interaction, teacher initiated behavior was highest for Logo across age groups. Thus, an apparent interaction existed among treatment, teacher initiation, and level of cognitive distancing.

It is also significant to note that Level III behaviors, both teacher initiated and child initiated, met with a high rate of successful response on the part of the child, ranging from 72 to 82 percent. Interactions in the

instructional software environment were more often of Level I or Level II distance. Instructional software contained its own reinforcement and children often worked independently. In cases where children had demonstrated prior inability to work independently in the classroom setting, as was the case with some emotionally impaired older children and most very young children, this could be seen as an advantage of the instructional programs. In cases where children are impaired in the use of language and/or metacognitive skills, however, more teacher interaction might be seen as a positive influence. As it was, teacher initiated interactions in the instructional software environment included many instructions for the use of the programs rather than discussions of their content, and thus included very little abstract language.

In teacher-directed activities (control) interactions at Level I ranged from 66% in the five to eight year old groups to a striking 97% in the preschool group (there were no observations for eight to twelve year olds). The observed activities in both groups consisted of a high proportion of film strips, operations with manipulatives, or stories wherein most teacher-initiated interactions were confined to requests for perceptually salient material (e.g., "Show me the one that is big"; "What did you see in that picture?"). The materials themselves in no way constrained the level of interaction, yet teachers rarely moved beyond the lowest level of cognitive distancing. This occurred despite the strikingly high success rate on the part of the children

engaging in activities which demanded representational thinking during Logo instruction.

A question arises concerning this overwhelming lack of high distance behaviors initiated by teachers in the teacher-directed activity as compared to Logo. The low proportion of high distance behaviors in the IS group may be reflecting, to some extent, the content of the program; but in the control group teachers were free to choose a wide range of potentially cognitively stimulating materials. Why, then, the predominance of Level I behaviors? Pellegrini, Brody & Sigel (1985) examined whether adults' speech to handicapped children is similar to their speech to young children, i.e., containing fewer cognitive demands. Our sample consisted of predominantly language impaired children. Pellegrini, et al (1985) suggested the possible existence of an interaction style based on limitations. People, in an effort not to overload the impaired child, may limit their interaction to low-level demands when, in fact, the child may be capable of performing at higher levels. If teaching is based solely on the concrete (look and do) because of the notion of limited capacity in the child to process abstract concepts, development may be limited because the teacher never presents abstact concepts (Vygotsky, 1978).

A question of interest is whether this limited style of interaction reflects a particular training or whether it reflects the more basic desire to be understood. How much of this intended adaptive behavior is cued because of the

child's poor ability to respond verbally when, in fact, he may be able to comprehend at a higher level? Our data suggests that Logo, inasmuch as it enables the child to respond in a mode which is not verbal, may encourage teachers to attempt more abstract cognitive dialogue with children.

We noticed in Logo classes that teachers often embedded instruction in a narrative framework. The child was expected to use representational thought and to comprehend abstract language, but was able to respond with a computer command rather than with words. For example, a teacher was observed teaching two four year-olds using a single keystroke Logo program. Rather than directing them to make a circle or a square, she proposed the project of making a truck. She asked questions such as, "What do you think we need next?", "How can we make a wheel?", and "Where do you think people could go in that truck?"

If Logo instruction is oriented towards a series of products or toward the completion of specific tasks, then what children learn is not usable in any environment other than Logo. If, however, representational thought is developed through dialogue, thinking skills may well be transferrable. This implies that Logo training for teachers must move beyond specific abilities and beyond applicability to the computer domain. If, on the other hand, a teacher decides that there are innate prerequisites in Logo instruction and insists that children master one thing before another, if teachers do not abolish limited concepts

of "correctness", then disabled or delayed children will be doomed to fail in the teacher's eyes and ultimately in their own.

Study 2: Observational Data

Design of the study

This study intended to explore, within the context of the larger study, the relation of the cognitive developmental level of the child to his computer behavior and to his ability to engage effectively in the Logo programming experience. Results of recent studies on Logo (e.g. Webb, 1984) had suggested that abilities which are already developed in the child affect the progress made in Logo instruction. Studies on the outcome of Logo instruction with normally developing children have been reporting variable findings with regard to the effect on cognitive development (e.g., Clements & Gullo, 1984; Pea & Kurland, 1984), but generally improvement was noted only in the specific skills which were taught within the programming experience, and not in the higher mental functions of planning and strategic problem solving. These results suggested that the variable of interest, Logo instruction, was not the only factor involved in the outcome. The intervening variables needed to be investigated as well.

We were interested in investigating the abilities which the children bring to the task of Logo instruction. We

sought a dynamic view of the child's cognitive development, one which provided us with some insight into the strategies or thinking processes he already had at his command, while also providing us with some measure of his level of cognitive development. This could be obtained in an investigation of the child's processes of concept attainment, which are defined by Bruner (1956) as the "search for and testing of attributes that can be used to distinguish exemplars from non-exemplars of various categories". The sequence of decisions made by the person en route to attaining the concept may be regarded as a strategy although not necessarily a conscious or deliberate one. Bruner felt that it was possible to describe and evaluate strategies in a relatively systematic way.

For this investigation we sought that method of externalizing the process so that it could be viewed and thus evaluated in a technique used by Vygotsky (1962). Vygotsky's methodology, on which we modeled our own, had the advantage of being related to a theoretical formulation which defined the various developmental stages which were represented by the different approaches to concept attainment used by children. Vygotsky (1962) had described three basic phases in the ascent to concept formation, each in turn divided into several stages. The first phase was characterized by an unorganized heaping of objects, first on a random, trial and error basis, then based on the child's immediate perceptions and on the spatial relationships between objects. In phase two, the child is beginning to

think in complexes. Individual objects are united in the child's mind not only in terms of the child's subjective impressions, but also in terms of bonds that actually do exist between these objects. These bonds are concrete and factual, not abstract or logical. At this level, the child has partly outgrown his egocentrism. Vygotsky describes five types of complexes with the final one, the "pseudo-concept", forming the bridge between complexes and the final, highest stage in the development of the ability to think in concepts.

In this experiment we used the descriptions of these phases and stages as a means of evaluating the behavior of children performing a block-sorting task modeled on the one used by Vygotsky in his study. The children selected for this task had also been observed during their activity at the computer in the context of the larger study, and their behavior had been recorded on the observation measure described previously. The Vygotsky task was administered by research assistants other than those who had observed the children in their computer environments. On the completion of the Vygotsky task, the two measures were compared as to the level of cognitive development suggested by each. It was hypothesized that the children who performed at a lower level on the Vygotsky task, which was a means of measuring cognitive development and the ability to use strategies in concept formation, would also display low levels of computer behavior in Logo, with little evidence of pre-planning ability or strategic monitoring of their activities.

Method

Subjects

Fifteen children, ranging in age from 7-0 to 12-3, were randomly selected from the larger group of children who had been in the study for two years, and had been in the Logo treatment group. There were 8 boys and 7 girls, selected from three of the four schools in the larger study, eliminating the one school which served the preschool and kindergarten population.

Procedure

The material used in the concept formation task consisted of 22 wooden blocks varying in color, shape, height and size. There were three colors, five shapes, two thicknesses, and two sizes of horizontal surface (large and small). The underside of the blocks was labeled with a small sticker. On the sticker was a plus sign placed on all large, thick blocks, regardless of color or shape, or a dash, placed on all small thick blocks, a blank sticker on all small thin blocks, and a happy face on all large thin blocks. This was the target block, the concept to be developed being "large/thin".

The child was shown all the blocks, scattered on the table in front of him, and the experimenter pointed out that there were different colors and different shapes, and that some of the blocks were thick and some were thin. The

examiner then turned up one of the large, thin blocks and asked the child to pick out all the blocks which he thought might belong to the same kind. A record was made of the choices made by the child, and the order in which he/she made the choices. After the child made the first grouping, the examiner turned up one of the "wrongly" selected blocks, showed that this was a block of a different kind, and encouraged the child to keep on trying. After each new attempt another of the "wrong" blocks was turned up. As the number of the turned blocks increased, the child was afforded a chance to obtain, by degrees, a basis for discovering to which characteristics of the block the happy face referred, and thence to complete the task of separating out the five blocks which fit within this new concept.

Results and discussion

The classification is based on not one but on two characteristics of the blocks which, in their combination, yield the subclass. The classification ignores the more perceptually compelling attributes of color and shape, and is based on size and thickness. The requirement to combine two characteristics and to form a new and less easily defined one is what makes this a concept attainment task. The concept to be formed is not supported by already existing simple names which the subject may have at hand (e.g., red, round). The value of the task lies in the possibility of a detailed analysis of the procedure used by the subject. His/her manipulations of the blocks reflect

the steps of his/her reasoning, forming hypotheses, testing and discarding them. Even if the subject does not attain the concept (and none of ours did), one can see the structure of pre-conceptual thinking on the different levels of its development, as characterized along the lines established by Vygotsky (1962).

All but one of the 15 subjects in this study had attained the second phase of Vygotsky's "ascent to concept formation", that is, they had progressed beyond the young child's tendency to put together a number of objects into unorganized heaps either randomly or on the basis of their spatial relationship to each other. The one child who did not pass this level was later found to be young (M.A. 7-3), and with severe developmental disabilities (IQ 42). The other children were able to think in complexes in which objects were united, not only in terms of the child's subjective impressions, but also in terms of bonds which actually exist between the objects. However, these children had attained different stages within this phase, in the developmental progression defined by Vygotsky.

Those children who were at the first stage, in which objects were associated by virtue of similarities to a nucleus object (the sample) or by perceptually compelling ties, were also the children who were, in computer instruction, doing one of two single keystroke programs: Easy Logo or Early Logo. These programs involve no programming ability, but instruct the child in moving the turtle back and forth and having the turtle go to a

predetermined goal on the monitor, or through a maze. As to the ratings of these children on the observation instrument, none had progressed beyond the "single main goal" (Level III), in which the goal is not preplanned, but what the child does seems to drive what he/she does next. The children in that group who were at Level II on the observation instrument (simple main goal) were all below the age of eight. The one child in that age category who was at stage 1 on the Vygotsky task and at Level III (single main goal) on the instrument was found to have an IQ somewhat higher than the other children of that age and stage (IQ 88). The children in this group were also observed to utilize a great deal of teacher involvement during the activity.

In rather striking contrast, the five children who attained the highest stage of conceptual development in this phase of the sequence (thinking in complexes), in which they are able to group attributes which are not perceptually compelling and can include more than one attribute within the group, were the same ones who had progressed to Apple Logo or to Delta Draw. These children achieved levels of performance on the behavioral measure in which they solved problems involving at least one main goal and one sub-goal, and in which they pre-planned an activity involving more than one learned procedure. The three children who were at a slightly lower stage on the Vygotsky scale, in which they were able to develop chained complexes, were those who, on the behavioral scale, were able to initiate a sequence of

actions involving pre-planning and use of learned procedures, but who were still focused on a single main goal. The oldest of these children (M.A. 9-9) had progressed to Apple Logo.

A review of this data suggests that the original hypothesis was correct: a child's ability to benefit from instruction in Logo programming is strongly related to the level of cognitive development which he has attained. Furthermore, it was seen that, while both age and IQ influence the attained level, age is the stronger factor in this determination. Of those who attained the highest level of functioning on the Vygotsky task, not one was younger than 9-6. The two older children (M.A. 9-11 and M.A. 12-3) who had reached only the first stage in the phase of complexes both had IQ's of 52. Thus, the child with a low IQ can be considered developmentally younger with regard to the measured behaviors in this study.

Thus, as in all other areas of instruction, curriculum development in computer education must be sensitive to and take into account the stage of cognitive development of the child for whom the curriculum is designed. The fact that development in this area is delayed, disturbed or impaired in the child with developmental disabilities such as speech/language impairment, retardation, or learning disabilities makes it especially important to consider the efficacy of such instruction for this population, as well as the means by which the computer's potential as an adjunct to the classroom can be realized. It must always be kept in

mind that computer instruction is an interactive process wherein the teacher, the child, and the computer play equally important roles. Further study of the appropriate use of computers in the education of handicapped children should be undertaken.

General Discussion

The two studies which have been presented strongly suggest that, while the child's ability to profit from instruction in Logo is related to his/her level of cognitive development, proper teaching methods which take into account the zone of proximal development may be able, through distancing or other methods, to move the child along at a faster rate or even to help develop what is intrinsically lacking in the child. Learning which is oriented toward developmental levels that have already been reached may be ineffective from the viewpoint of a child's overall development. It does not aim for a new stage of the developmental process but rather lags behind this process. Teaching which is oriented toward the development of specific subskills, and relies heavily on what is provided in commercially available teaching materials and computer software, may also be neglecting an opportunity to facilitate the child's cognitive developmental processes.

If we adopt the view proposed by Vygotsky, that an essential feature of learning is that it creates the zone of proximal development, then we might reexamine our goals and

methodology in teaching the handicapped learner. If we go the next step with Vygotsky, and accept the idea that learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers, then we must examine teaching process and methodology in regular and special education and give it its proper place of importance over materials and programs.

The results of the observation data reported in the first study suggest that teachers using Logo in contrast to the other two treatments tended to engage in higher level interactions with students, i.e., they encouraged more active processing on the part of the child, and demanded more abstract and representational thinking. Children, of similar cognitive and developmental levels to those in the other two groups, were able to perform successfully at these higher levels, while their peers in the other two groups tended to function at lower levels of cognitive distancing. These observations lend support to the notion of the zone of proximal development as an important factor in the learning process. That is, within the range of possibility created by the attained developmental level of the child, there is a great deal of potential for learning which is more likely to be tapped if teachers are sensitive to the concept of the zone of proximal development, and are trained to use teaching methods which stimulate overall cognitive development.

The answer may not be found in current trends in cognitive behavior modification, in which children are trained in specific strategies and tactics that demonstrably do improve performance in various tasks. It has not been demonstrated that there is transferability or generalizability of these skills, particularly with handicapped learners, although there are those (e.g. Meichenbaum & Goodman, 1971) who propose that behavior change leads to cognitive change. The reason for this lack of generalizability may be found in an essential aspect of Vygotsky's theory, which is that developmental processes do not coincide with learning processes. When a child masters an operation, or assimilates a new word meaning, the developmental process is not completed--it is only just begun. Initial mastery of specific skills provides the basis for the subsequent development of a variety of highly complex internal processes in the child's thinking. It is the job of adults in the child's learning environment to facilitate this next stage of the developmental process. The results of the studies reported in this paper have suggested a direction for thinking about how this might best be accomplished. Further study of the role played by the teacher and computer in promoting cognitive development in children, especially in handicapped learners, should be undertaken.

References

Borkowski, J.G., & Cavanaugh, J.C. (1979). Maintenance and generalization of skills and strategies by the retarded. In N.R. Ellis (Ed.), Handbook of mental deficiency: Psychological theory and research (2nd ed.). Hillsdale: Erlbaum.

Brown, A.L. (1980). Metacognitive development and reading. In R. Spiro, B. Bruce & W. Brewer (Eds.), Theoretical Issues in Reading Comprehension. Hillsdale, N.J.: L. Erlbaum Assoc.

Brown, A.L. (1981). Metacognition: The development of selective attention strategies for learning from tests. In M. Kamil (Ed.), Directions in reading: Research and instruction. Thirtieth yearbook of the National Reading Conference. Washington, D.C.: National Reading Conference.

Brown, A.L. (1982). Learning and development: The problems of compatibility, access and induction. Human Development, 25, 89-115.

Brown, A.L., Bransford, J., Perrara, R. & Campione, J. (1983). Learning, remembering and understanding. In J. Flavell & E. Markman (Eds.), Handbook of Child Psychology: Cognitive Development. (pp.77-166). New York: Wiley.

Brown, A.L. & DeLoache, J.S. (1978). Skills, plans, and self-regulation. In R. Siegler (Ed.), Children's Thinking What Develops? Hillsdale, New Jersey: Erlbaum.

Bruner, J., Goodnow, T., & Austin, J. (1956). A Study of Thinking.

Bruner, J., Oliver, R., Greenfield, P. et al. (1967). Studies in Growth. New York: Wiley.

Bucher, B., & Lovaas, O. (1967). Use of aversive stimulation in behavior modification. In M. Jones (Ed.), Miami Symposium on the prediction of behavior: Aversive stimulation. Coral Gables, Fla.: University of Miami Press, 35-51.

Budoff, M. & Hutton, L.R. (1982). Microcomputers in special education: Promises and pitfalls. Exceptional Children, 49, 123-128.

Clements, D.H. & Gullo, D.F. (1984). Effects of computer programming on young childrens' cognition. Journal of Educational Psychology, 76, No. 6, 1051-1058.

Copeland, A.P. & Weissbrod, C.S. (1983). Cognitive strategies used by learning disabled children: Does hyperactivity always make things worse? Journal of Learning Disabilities, 16, No.8.

Feuerstein, R. (1980). Instrumental Enrichment. Baltimore:

University Park Press.

Harckham, L., de Bernard, A., Ferber, G., & Vota, C. (October, 1985) The impact of microcomputer instruction on handicapped students: Second year findings. Paper presented at Northeast Educational Research Association, Kerhonksen, N.Y.

Lehrer, R. (April, 1985). The language of learning and the language of computing. Paper presented at American Educational Research Association, New Orleans, LA.

Lindsley, O. (1969). Public address on behavior therapy. University of Washington, Seattle.

Meichenbaum, D. & Goodman, J. (1971). Training impulsive children to talk to themselves: A means of developing self-control. Journal of Abnormal Child Psychology, 77, 115-126.

Papert, S. (1980). Mindstorms. New York: Basic Books.

Pea, R.D. (1984). Logo programming and problem solving. Technical report No. 12, Bank Street College of Education, Center for Children and Technology.

Pellegrini, A.D., Brody, G.H., & Sigel, I.E. (1985). Parents' book-reading habits with their children. Journal of Educational Psychology, 77, No. 3, 332-340.

Piaget, J. (1952). The origins of intelligence in children. New York: International Universities.

Piaget, J. (1964). Development and learning. In R.E. Ripple and V.N. Rockcastle (Eds.), Piaget Rediscovered. Ithaca, New York: Cornell University Press.

Sigel, I.E. (1970). The distancing hypothesis: a causal hypothesis for the acquisition of representational thought. In M.E. Jones (Ed.), Miami Symposium on the prediction of behavior, 1968: Effect of early experiences. Florida: University of Miami Press.

Sigel, I.E. & Cocking, R.R. (1977). Cognition and communication: a dialectic paradigm for development. In M. Lewis and L. Rosenbaum (Eds.), Interaction, conversation, and the development of language. New York: Wiley.

Skinner, B.S. (1938). The behavior of organisms: An experimental analysis. Englewood Cliffs, New Jersey: Prentice Hall.

Smith, J. (1968). The effects of training procedure upon the acquistion of conservation of weight. Child Development, 39, 515-526.

Sullivan, E. (1968). Piagetian theory in the educational milieu: a critical appraisal. Unpublished manuscript, Ontario Institute for Studies in Eduction.

Thorndike, E.L. (1913). The psychology of learning. New York: Teachers College.

Torgesen, J.K. (1977). Memorization processes in learning disabled children. Journal of Educational Psychology, 69, 571-578.

Torgesen, J.K., Murphy, H.A., & Ivey, C. (1979). The effects of an orienting task on the memory performance of learning disabled children. Journal of Learning Disabilities, 12, 396-401.

Vota, C. (October, 1985). Review and evaluation of childrens' software in education. Paper presented at Northeastern Educational Research Association, Kerhonksen, N.Y.

Vygotsky, L.S. (1962). Thought and Language. Cambridge, Mass.: MIT Press.

Vygotsky, L.S. (1978). Mind in Society. Cambridge, Mass.: Harvard University Press.

Webb, N.R. (1984). Microcomputer learning in small groups: Cognitive requirements and group processes. Journal of Educational Psychology, 76, No. 6, 1076-1088.

OBSERVATION INSTRUMENT

I.

OBSERVE: looks at teacher, watches a demonstration.

0 1 2

LABEL: simple objects or actions.

0 1 2

RECOGNITION AND LABELING OF READINESS CONCEPTS:

colors, numbers, shapes or letters.

0 1 2

ANSWERING: yes/no response or completes modeled phrase.

0 1 2

DESCRIBING: attribute (not function)

0 1 2

MATCHING: one to one (letters to keys, card to card)

0 1 2

CATEGORY SEARCH: without model. ex: find the "p".

0 1 2

II

ESTIMATION: How many

0 1 2

COMPARISON:

compares attributes not function "Which one is yellow?"

0 1 2

SEQUENCE COMPLETION:

what comes next or what is missing.

0 1 2

SEQUENCE REARRANGEMENT:

rearranges jumbled cards or events into coherent sequence.

0 1 2

DESCRIBE CONCEPTUAL SIMILARITIES/ DIFFERENCES:

this is like this - this goes with this because ...

0 1 2

SKILL DEVELOPMENT:

"drill and practice" guided by instructional software: add/sub letter to picture

0 1 2

LEVEL I (contd.) ENUMERATION

ordinal counting 1 - 2 - 3 ...

0 1 2

III

SIMPLE MAIN GOAL:

no pre-planning - navigates turtle to goal - teacher directed.

0 1 2

CHILD INITIATES SEQUENCE OF ACTIONS TO ATTAIN A SINGLE MAIN GOAL:

3 or more chained actions - child makes letter or shape with LOGO.

0 1 2

STRATEGIC MONITORING I

take corrective action - either inst. software or LOGO.

0 1 2

CHILD INITIATES SEQUENCE OF ACTIONS TO ATTAIN A SINGLE MAIN GOAL

effectively achieves goal - result of practice not random.

0 1 2

CHILD SOLVES PROBLEM INVOLVING AT LEAST 1 SUBGOAL AND A MAINGOAL

ex: flag = rectangle + pole - 2 procedures.

0 1 2

STRATEGIC PLANNING

decides on and creates novel procedures to achieve complex goal

0 1 2

STRATEGIC MONITORING II

evaluates utility of procedure - rethinks reprograms

0 1 2

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